Profitability, input demand and output supply of mustard production in Bangladesh

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ABSTRACT

This paper estimates profitability, input demand and output supply of mustard production at the farm-level in Bangladesh utilizing a survey data of 206 mustard farmers from two regions of Bangladesh by applying a profit function approach. Mustard production is profitable at the farm level (Benefit Cost Ratio = 1.34) with no adverse influence of farm size on yield and profitability. Mustard farmers are also responsive to changes in market prices of inputs and outputs. Mustard price is the most dominant determinant of output supply and input demand. A 1% increase in mustard price will increase output supply by 0.62% and increase demand for mechanical power, fertilizer and labour by 1.06%, 1.05% and 1.01%, respectively but will decrease seed demand by 3.96%. The fixed factors have no role except land fragmentation substantially reducing seed demand. Policy implications include price policy to improve mustard price and tenurial reform aimed at improving land fragmentation and smooth functioning of the hired labour market in order to increase production and profitability of mustard in Bangladesh.

Key words: Profitability; output supply; input demand; translog profit function; mustard; Bangladesh

1. INTRODUCTION

Rapeseed-mustard (*Brassica* spp) or mustard is a major oilseed crop in the world which is grown in 53 countries across six continents including India which is the second largest producer after China (Boomiraj et al., 2010). Mustard is also the most dominant oilseed crop in Bangladesh and has experienced expansion in area, production and yield over time while facing fierce competition of land for production of cereals, e.g., rice, wheat and maize. For example, the total cropped area of mustard has increased from 317,800 ha in 2001 to 294,206 ha in 2014;

production from 238,000 t to 296,000 t; and yield from 0.75 t/ha to 1.20 t/ha during the same period (MoA, 2007; BBS, 2016). In fact mustard alone covers 80% of the total area under oilseed crops (Miah et al., 2015). The country is producing about 0.36 million tons of edible oil per year as against the total requirement of 1.4 million tons (Mallik, 2013). As a consequence, Bangladesh remains as a net importer of oils and the demand for oil will increase substantially in the future in response to increase in population and changes in dietary habits and nutritional awareness. For example, import of mustard oil has increased from BDT 2.42 million in 2006 to BDT 50.59 million in 2014, which is extraordinarily high (BBS, 2016). One of the main reasons may be the replacement of high volume of palm oil import as observed during 2006 with mustard and soybean oils for consumption as observed during 2010 (BBS, 2014). Mustard is a predominantly winter crop and is sown during mid-October to November and harvested during late January to end of February. Given the future scenario of climate warming, it is recognised that the winter crops, such as mustard, other oilseeds and vegetables, are likely to be relatively more vulnerable to rising temperatures, which will add further pressure on increased demand for oils. For example, Boomiraj et al. (2010) noted that mustard production in India is likely to reduce in the future under both irrigated and non-irrigated condition and recommended adaptation of late sowing strategy and/or developing longer duration varieties to cope.

A limited number of socio-economic investigations were made on mustard cultivation in Bangladesh largely focusing on factors influencing adoption of modern technology and/or perception of the farmers. For example, Miah et al. (2015) noted that the adoption of improved varieties is not encouraging in Bangladesh as only about 40% of the surveyed farmers has adopted. Hossain *et al*. (2013) examined farmers' perception on cultivating mustard between the two main rice crops, i.e., Aman rice (monsoon) and Boro rice (dry winter). They noted that farmers have high level of perception about the crop and that profitability of the technology, knowledge on mustard cultivation and risk orientation explained 71% of the variations in perception, implying that profitability of mustard production is a major issue.

Studies on profitability of mustard production at the farm level in Bangladesh are not widely available although results from experimental stations are available. For example, Mondal et al. (2008) conducted a field experiment research at the regional station of the Bangladesh Agricultural Research Institute (BARI) located in Jessore district by varying tillage and mulching options in mustard production and reported productivity ranging from 1.9 to 2.7 t/ha and Benefit Cost ratio (BCR) of 1.06 to 1.97. Similarly, Azam et al. (2013) conducted experiments of varying zinc fertilizer doses on mustard in the same research station and reported its significant influence on productivity ranging from 1.17 t/ha in control plots to 1.42 t/ha in treatment plots with corresponding BCR of 1.34 and 1.57, respectively. But such results are not comparable to farm level conditions as these estimates are obtained under controlled experimental conditions.

Most importantly, the nature of responsiveness of the mustard farmers to changes in input and output prices are not known at all. This information is important because Bangladesh farmers not only need to be more efficient in their production activities, but also to be responsive to market indicators, so that the scarce resources are utilized efficiently to increase productivity as well as profitability in order ensure supply to the urban market (Rahman, 2003) and increase farmers' welfare. Furthermore, the government of Bangladesh is seeking to diversify its agricultural sector to other cereals (i.e., wheat and maize) as well as non-cereals (e.g., potatoes, vegetables, and spices, etc.). In fact, the Fifth Five Year Plan (1997–2002) emphasized and set specific objectives to attain self-sufficiency in foodgrains production and increased production of other nutritional crops and earmarked 8.9% of the total agricultural allocation to promote crop diversification (PC, 1998). Subsequently, the Poverty Reduction Strategy Paper (2005) and the Sixth Five Year Plan (2011–2015) also emphasized crop diversification (PC, 2011; IMF, 2005).

Given this backdrop, the present study specifically addresses this critical research gap in knowledge on the farm-level profitability and nature of responsiveness of the mustard farmers to input and output price changes by systematically examining profitability and responsiveness of the mustard producers to market forces using an in-depth farm survey data of 206 farmers from two major mustard growing regions in central Bangladesh (i.e., Tangail and Sirajganj districts). Specifically, the study aims to: (i) Assess financial profitability of producing mustard at the farm level and (ii) Estimate input demand and output supply elasticities of mustard production at the farm level.

The paper is organised as follows. Section 2 presents the analytical framework, the study area and the data. Section 3 presents the results. Section 4 provides conclusions and draws policy implications.

2. METHODOLOGY

We apply two main analytical tools to address these two objectives. (a) Cost-Benefit Analysis (CBA) to determine financial profitability of mustard production at the farm level and (b) translog profit function to estimate input demand, output supply and fixed factor elasticities of mustard production at the farm level. The details are as follows.

2.1 Profitability analysis of mustard

Profitability or Cost-Benefit Analysis (CBA) includes calculation of detailed financial costs of production and returns from mustard on a per hectare basis. The total cost (TC) is composed of total variable costs (TVC) and total fixed costs (TFC) (Rahman and Rahman, 2014). TVC includes costs of human labour (both family labour and hired labour, wherein the cost of family labour is estimated by imputing market wage rate), mechanical power; seed, manure, chemical fertilizers; pesticides; and irrigation. TFC includes land rent (if owned land is used then the imputed value of market rate of land rent is applied) and interest on operating capital. The gross return (GR) is computed as total mustard output multiplied by the market price of mustard. Profits or gross margin (GM) is defined as GR–TVC, whereas the Net return (NR) is defined as GR–TC. Finally, the Benefit Cost Ratio (BCR) is computed as GR/TC (Rahman and Rahman, 2014).

2.2 The profit function approach

A profit function approach is used to examine impacts of prices and fixed factors on farmers' resource allocation decisions. This is because profit function has a duality relationship with the underlying production function. An advantage of a profit function model is that it is specified as a function of prices and fixed factors which are exogenous in nature and, therefore, are free from possible endogeneity problem associated with a production function model (Rahman et al., 2012). The basic assumption is that farm management decisions can be described as static profit maximization problem. Specifically, the farm household is assumed to maximize 'restricted' profits from growing specific crops, defined as the gross value of output less variable costs, subject to a given technology and given fixed factor endowments (Rahman and Parkinson, 2007).

A flexible functional form, the translog function was used that approximates most of the underlying true technology. The general form of the translog profit function, denoting the *i*th subscript for the farm, is defined as:

$$\ln \pi' = \alpha_0 + \sum_{j=1}^{4} \alpha_j \ln P'_j + \tfrac{1}{2} \sum_{j=1}^{4} \sum_{k=1}^{4} \gamma_{jk} \ln P'_j \ln P'_k + \sum_{j=1}^{4} \sum_{l=1}^{4} \delta_{jl} \ln P'_j \ln Z_l$$

$$+\sum_{l=1}^{4}\beta_l \ln Z_l + \tfrac{1}{2}\sum_{l=1}^{4}\sum_{t=1}^{4}\theta_{lt}\ln Z_l \ln Z_t + v, \quad (5)$$

where:

π' = restricted profit (total revenue less total cost of variable inputs) normalized by price of output (P_y),

P'_j = price of the *j*th input (P_j) normalized by the output price (P_y),

j = 1, fertilizer price,

= 2, labour wage,

= 3, mechanical power price,

= 4, seed price,

Z_l = quantity of fixed input, l,

l = 1, area under mustard,

= 2, experience,

= 3, education,

= 4, land fragmentation,

v = random error,

ln = natural logarithm, and

$\alpha_0, \alpha_j, \gamma_{jk}, \beta_l, \delta_{jl},$ *and* $\theta_{lt},$ are the parameters to be estimated.

The corresponding share equations are expressed as,

$$S_j = -\frac{P_j X_j}{\pi} = \frac{\partial \ln \pi'}{\partial \ln P'_j} = \alpha_j + \sum_{k=1}^{4}\gamma_{jk}\ln P'_k + \sum_{l=1}^{4}\theta_{jl}\ln Z_l, \quad (6)$$

$$S_y = \frac{P_y X_y}{\pi} = 1 + \frac{\partial \ln \pi'}{\partial \ln P_y} = 1 + \sum_{j=1}^{4}\alpha_j + \sum_{j=1}^{4}\sum_{k=1}^{4}\gamma_{jk}\ln P'_j + \sum_{j=1}^{4}\sum_{l=1}^{4}\theta_{jt}\ln Z_l, \quad (7)$$

where S_j is the share of jth input, S_y is the share of output, X_j denotes the quantity of input j and Y is the level of output. Since the input and output shares form a singular system of equations (by definition S_y - ΣS_j = 1), one of the share equations, the output share, is dropped and the profit function and variable input share equations are estimated jointly using SURE procedure using STATA V10 econometric software program (Stata Corp, 2007). The joint estimation of the profit function together with factor demand equations ensures consistent parameter estimates (Sidhu and Baanante, 1981).

2.3 Data and the study area

The data to analyse profitability, output supply and input demand of mustard production at the farm level was taken from a recently completed NFPCSP-FAO project. The data was collected during February–May 2012 through an extensive farm survey in 17 districts (or 20 sub-districts) of Bangladesh. A multistage stratified random sampling technique was employed. At the first stage, districts where the specified crops are dominant are selected which includes mustard as one of the crops. At the second stage, sub-districts (upazilla) were selected according to highest concentration of these specified crops in terms of area cultivated based on information from the district offices of the Directorate of Agricultural Extension (DAE). At the third stage, unions were selected using same criteria at the union/block level which was obtained from the upazilla offices of the DAE. Finally, the farmers were selected at random from the villages with the same criteria classified by three standard farm size categories. These are: marginal farms (farm size 50–99 decimals), small farms (100–249 decimals), and medium/large farms[1] (>250 decimals) (Hossain 1989; Hossain et al., 1990). Specifically, information on mustard production was

[1] We have excluded functionally landless households (farm size <0.50 decimal) defined by Hossain (1989) and Hossain et al. (1990) in our sampling strategy because the main focus of the study is to explore the prospect of crop diversification amongst the farming households of Bangladesh.

collected from two districts where it is dominant. These are Tangail and Sirajganj districts in central region. Although a total of 210 mustard producing households (70 marginal farms, 70 small farms and 70 medium/large farms) were interviewed, full information necessary for this study is available for only 206 farmers which is the final sample size. The questionnaire used was pre-tested in the non-sampled villages from Tangail district prior to finalization. The survey was carried out by trained enumerators who are graduate students at the Sher-e-Bangla Agricultural University, Dhaka and/or Bangladesh Agricultural University, Mymensingh (For details, see Kazal et al., 2013).

3. RESULTS

3.2 Financial profitability of mustard production

Table 1 presents profitability information of mustard production. It is clear from Table 1 that mustard production is profitable based on the net return and BCR in the central region of Bangladesh. The average yield is estimated at 1.48 t/ha and the net return is estimated at BDT 18,857.41 per ha with BCR of 1.34. Although the yield, net return and BCR were higher relatively for the small farms, there is no significant difference amongst of these measures amongst farm sizes as evidenced from the Chi-squared test results (Table 1). The implication is that farm size has no influence on the yield and profitability of mustard production, which is encouraging given that a largely majority of the farmers in Bangladesh is either marginal or small. The estimated mustard yield of 1.48 t/ha is substantially higher than the yield of 0.81 t/ha in Nepal (Dhakal et al., 2015) and closely comparable to the experiment station yield levels reported by Azam et al. (2013). The computed BCR of 1.34 is lower than mustard production in Nepal estimated at 1.43 (Dhakal et al., 2015), maize estimated at 1.63 (Rahman and Rahman, 2014) and wheat at 1.40 (Hasan, 2006) but higher than Boro rice at 1.14 (Baksh, 2003) in

Bangladesh. The implication is that mustard production can compete with the major rice crop in Bangladesh.

3.3 Output supply, input demand and fixed factor elasticities of mustard production

One main limitation and/or criticism in applying a profit function model in a cross-section of data is the lack of variation in input and output prices (Rahman and Hasan, 2011). The geographical dispersion of the sampled farmers and imperfections in the input markets in Bangladesh ensure adequate variability in prices at any given point in time. However, a valid test is required to confirm this intuition. In our sample, mustard price varied from BDT 32.50–70.00 per kg; fertilizer price (average price of 5 types of fertilizers used) varied from BDT 5.00 to 17.22 per kg; labour wage varied from BDT 175–418.75 per person day; mechanical power price varied from BDT 4.01–42.43 per decimal of land and seed price varied from BDT50.00–120.00 per kg, respectively. A formal t-test for differences in the prices of mustard, fertilizers, labour wage, mechanical power services and seed between the two districts rejected the null-hypothesis of 'no-difference' at 1% level of significance, thereby confirming that significant price variations exist in our sample, and hence, the application of the profit function model is justified (Table 2).

Tables 3 presents the estimates of the profit function estimated jointly with four input demand equations for mustard. Among the regularity properties of the profit function specified in equation (5), homogeneity was automatically imposed because the normalized specification was used (Rahman and Parkinson, 2007). The monotonicity property of a translog profit function model holds if the estimated output share is positive (Wall and Fisher, 1987 cited in Farooq et al., 2001) which was found true in present case. The symmetry property was tested by imposing cross-equation restrictions of equality on the corresponding parameters between the profit function and the four factor demand equations. The test failed to reject the restrictions thereby confirming that the symmetry property also holds and the sample farms do maximize profit with respect to normalized prices of the variable inputs (Sidhu and Baanante, 1981). The convexity property was assumed to hold and was not tested.

The parameter estimates of the profit function model are used to estimate the elasticities with respect to variable input demand, output supply and fixed factors (Table 4). All own price elasticities have negative signs consistent with theory, but all of them are in the inelastic range except labour which is in the elastic range. Results of the cross-price elasticities of demand are mixed with some being complements and some being substitutes.

On the whole, changes in market price of inputs and output significantly influence farmers' resource use and productivity (mustard supply) as expected. The output supply response to output price change is positive, consistent with theory. The elasticity value of 0.62 indicates that a one per cent increase in mustard price will increase output supply by 0.62%. The output supply response is higher than for HYV rice estimated at 0.27 (Rahman and Parkinson, 2007) but much lower than HYV wheat estimated at 0.95 (Rahman et al., 2012) in Bangladesh. Mustard price is the most dominant driver. For example, the demand for mechanical power, fertilizer and labour will increase by 1.06%, 1.05% and 1.01%, respectively for a one percent increase in mustard price. The rise in labour demand in response to mustard price increase will lead to a redistribution of gains accrued from mustard production to landless labourers via wages, an argument in favour of widespread diffusion of modern agricultural technology in Bangladesh (Rahman and Hasan, 2011). In fact, labour input alone accounts for a substantial 36.4% of the total input costs in mustard production. However, an increase in the demand for pesticide in response to a rise in mustard price is a cause of concern although the influence is lowest (Table 4). However, results also show that a one percent increase in mustard price will decrease seed demand by 3.96%, because an increase in the output price is likely to be carried on to a corresponding increase in seed price. . But this should not be a major cause of concern because farmers use relatively fixed amount of seed in the production process.

The responsiveness of labour demand to wage increase is in the elastic range. This is expected because labour is the main variable input in mustard production as mentioned above. Therefore, the farmers' response to a rise in wage is quite high estimated at –1.01 implying that a one percent increase in labour wage will reduced labour demand by 1.01%. Elastic response of labour demand to a rise in wage was also reported for HYV wheat in Bangladesh estimated at –1.11 (Rahman et al., 2012) which is very close to our estimate for mustard crop. The own price elasticity of other inputs are in the inelastic range low and similar to those reported for HYV rice (Rahman and Parkinson, 2007) and HYV wheat (Rahman et al., 2012).

Among the conventional fixed factors, there is no role of land area in influencing productivity and resource use. This may be due to the fact that farmers decide to allocate a fixed amount of land for growing mustard which is mainly for sale and allocate the rest of the land area to produce the main rice crop in order to meet subsistence and other needs. For example, Hossain et al. (1990), based on a nationally representative sample survey of 1345 households from the 62 districts of Bangladesh, noted that oilseeds occupied only 2.4% and rice (traditional and modern varieties) occupied a substantial 71.8% of the gross cropped area. Similarly, Rahman (1998), based on a sample of 406 households from 21 villages from three districts of Bangladesh, noted that oilseeds occupied only 3.1% and rice (traditional and modern varieties) occupied 79.2% of the gross cropped area. Although irrigation is important in field crop production such as rice, wheat, maize and/or vegetables, most farmers did not use any supplementary irrigation in mustard production. Hence, irrigation variable is excluded from the analysis. Similarly, experience and land fragmentation do not seem to have any influence on output supply and input demand except a detrimental effect of land fragmentation on seed demand.

4. Conclusions and policy implications

The principal aim of this study is to assess financial profitability and responsiveness of mustard farmers to price changes at the farm level. Results revealed that mustard production is profitable at the farm level (BCR = 1.34) with no adverse influence of farm size on yield as well as profitability. The average yield of mustard is 1.48 t/ha and a net return of BDT 18,857.41 per ha. Farmers are responsive to changes in market prices of mustard and inputs although the level of responsiveness is low. The dominant driver of mustard supply and input demand is mustard price. A rise in mustard price will increase output supply by 0.62% and demand for mechanical power, fertilizer and labour inputs by 1.06%, 1.05% and 1.01%, respectively. Experienced farmers exert negative influence on output supply and input demand for mustard production with no influence of land availability on these measures.

The following policy implications can be derived from the results of this study. First, price policy to improve the price of mustard will increase mustard supply as well as demand for inputs including labour use. Second, tenurial reform aimed at improving land fragmentation to consolidate farm sizes through modification of law of inheritance and regulations to prevent land fragmentation (Rahman and Rahman, 2008). And third, policies to facilitate smooth operation of the hired labour market which will in turn enable the landless labourers to reap the benefits of increase mustard production through wages. This is because labour is the major input in mustard production. Effective implementation of these policy measures, although formidable, will boost mustard production.

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Table 1: Financial profitability of mustard production by farm size in central region (Tangail and Sirajganj districts)

Region and farm type	Yield (t/ha)	Sale price (BDT/t)	Gross return (BDT/ha)	Variable cost (BDT/ha)	Total cost (BDT/ha)	Gross margin (BDT/ha)	Net return (BDT/ha)	Undiscounted BCR
All	**1.48**	**47,846.19**	**74,017.62**	**31,729.49**	**55,160.22**	**42,288.13**	**18,857.41**	**1.34**
Marginal (<0.50 decimals)	1.41	48,560.71	72,291.86	31,268.57	55,017.49	41,023.29	17,274.38	1.31
Small (0.50 – 2.49 decimals)	1.50	47,853.57	74,974.93	30,847.96	53,950.15	44,126.96	21,024.78	1.39
Medium & Large (>2.50 decimals)	1.52	47,124.29	74,786.08	33,071.93	56,513.01	41,714.15	18,273.07	1.32
χ^2	0.11						0.74	

Note: Exchange rate: USD 1.00 = BDT 81.86 in 2012 (BB, 2013)

Table 2. Price variation between districts

Prices	Measurement	Tangail	Sirajganj	t-statistic
Mustard price	BDT kg^{-1}	45.57	50.19	-7.41***
Fertilizer price	BDT kg^{-1}	11.88	11.44	2.20**
Labour wage	BDT $person\text{-}day^{-1}$	333.04	199.76	43.57***
Mechanical power price	BDT $decimal^{-1}$	10.72	6.59	6.83***
Seed price	BDT kg^{-1}	68.47	51.14	21.22***

Note: Exchange rate: USD 1.00 = BDT 81.86 in 2012 (BB, 2013)

Table 3. Restricted parameter estimates of the translog profit function and factor share equations

Variables	Parameters	Coefficients	t-ratio
Profit Function			
Constant	α_0	2.6072	1.08
lnP'_F	α_F	-0.0041	-0.03
lnP'_W	α_W	-0.1366	-0.30
lnP'_M	α_M	0.0124	0.17
lnP'_S	α_S	0.0410	1.06
$½(lnP'_F \times lnP'_F)$	γ_{FF}	-0.0671***	-13.68
$½(lnP'_W \times lnP'_W)$	γ_{WW}	-0.2702***	-3.98
$½(lnP'_M \times lnP'_M)$	γ_{MM}	-0.0170***	-4.84
$½(lnP'_S \times lnP'_S)$	γ_{SS}	0.0084	0.52
$lnP'_F \times lnP'_W$	γ_{FW}	-0.1159***	-6.77
$lnP'_F \times lnP'_M$	γ_{FM}	-0.0090**	-2.31
$lnP'_F \times lnP'_S$	γ_{FS}	-0.0044*	-1.70
$lnP'_W \times lnP'_M$	γ_{WM}	-0.0173	-1.46
$lnP'_W \times lnP'_S$	γ_{WS}	-0.0225*	-1.84
$lnP'_M \times lnP'_S$	γ_{MS}	0.0001	0.06
$lnP'_F \times lnZ_A$	δ_{FA}	-0.0220	-0.98
$lnP'_F \times lnZ_I$	δ_{FI}	-0.0095	-0.27
$lnP'_F \times lnZ_L$	δ_{FL}	0.0098	1.41

Variables	Parameters	Coefficients	t-ratio
$lnP'_F \times lnZ_E$	δ_{FE}	-0.0360*	-1.83
$lnP'_W \times lnZ_A$	δ_{WA}	-0.0165	-0.25
$lnP'_W \times lnZ_I$	δ_{WI}	0.0198	0.19
$lnP'_W \times lnZ_L$	δ_{WL}	0.0184	0.91
$lnP'_W \times lnZ_E$	δ_{WE}	-0.1798***	-2.98
$lnP'_M \times lnZ_A$	δ_{MA}	-0.0255***	-2.35
$lnP'_M \times lnZ_I$	δ_{MI}	-0.0003	-0.02
$lnP'_M \times lnZ_L$	δ_{ML}	0.0051	1.51
$lnP'_M \times lnZ_E$	δ_{ME}	0.0108	1.07
$lnP'_S \times lnZ_A$	δ_{SA}	-0.0042	-0.79
$lnP'_S \times lnZ_I$	δ_{SI}	-0.0029	-0.36
$lnP'_S \times lnZ_L$	δ_{SL}	0.0015	0.95
$lnP'_S \times lnZ_E$	δ_{SE}	0.7539***	11.01
lnZ_A	β_A	0.4583	0.74
lnZ_I	β_I	0.0310	0.03
lnZ_L	β_L	-0.2718	-1.27
lnZ_E	β_E	0.4445	0.76
$\frac{1}{2}(lnZ_A \times lnZ_A)$	θ_{AA}	0.2121	1.56
$\frac{1}{2}(lnZ_I \times lnZ_I)$	θ_{II}	0.0579	0.21
$\frac{1}{2}(lnZ_L \times lnZ_L)$	θ_{LL}	0.0283	1.04
$\frac{1}{2}(lnZ_E \times lnZ_E)$	θ_{EE}	0.2476**	2.00

Variables	Parameters	Coefficients	t-ratio
lnZ_A x lnZ_I	θ_{AI}	-0.0620	-0.52
lnZ_A x lnZ_L	θ_{AL}	0.0228	0.84
lnZ_A x lnZ_E	θ_{AE}	-0.1667	-1.42
lnZ_I x lnZ_L	θ_{IL}	0.0235	0.54
lnZ_I x lnZ_E	θ_{IE}	-0.0234	-0.19
lnZ_L x lnZ_E	θ_{LE}	-0.0088	-0.33
Fertilizer share equation			
Constant	α_F	-0.0041	-0.03
lnP'_F	γ_{FF}	-0.0671***	-13.68
lnP'_W	γ_{FW}	-0.1159***	-6.77
lnP'_M	γ_{FM}	-0.0090**	-2.31
lnP'_S	γ_{FS}	-0.0044*	-1.70
lnZ_A	δ_{FA}	-0.0220	-0.98
lnZ_I	δ_{FI}	-0.0095	-0.27
lnZ_L	δ_{FL}	0.0098	1.41
lnZ_E	δ_{FE}	-0.0360*	-1.83
Labor share equation			
Constant	α_W	-0.1366	-0.30
lnP'_F	γ_{FW}	-0.1159***	-6.77
lnP'_W	γ_{WW}	-0.2702***	-3.98
lnP'_M	γ_{WM}	-0.0173	-1.46

Variables	Parameters	Coefficients	t-ratio
lnP'_S	γ_{WS}	-0.0225*	-1.84
lnZ_A	δ_{WA}	-0.0165	-0.25
lnZ_I	δ_{WI}	0.0198	0.19
lnZ_L	δ_{WL}	0.0184	0.91
lnZ_E	δ_{WE}	-0.1798***	-2.98
Mechanical power share equation			
Constant	α_M	0.0124	0.17
lnP'_F	γ_{FM}	-0.0090**	-2.31
lnP'_W	γ_{WM}	-0.0173	-1.46
lnP'_M	γ_{MM}	-0.0170***	-4.84
lnP'_S	γ_{MS}	0.0001	0.06
lnZ_A	δ_{MA}	-0.0255***	-2.35
lnZ_I	δ_{MI}	-0.0003	-0.02
lnZ_L	δ_{ML}	0.0051	1.51
lnZ_E	δ_{ME}	0.0108	1.07
Seed share equation			
Constant	α_S	0.0410	1.06
lnP'_F	γ_{FS}	-0.0044*	-1.70
lnP'_W	γ_{WS}	-0.0225*	-1.84
lnP'_M	γ_{MS}	0.0001	0.06

Variables	Parameters	Coefficients	t-ratio
lnP'_S	γ_{SS}	0.0084	0.52
lnZ_A	δ_{SA}	-0.0042	-0.79
lnZ_I	δ_{SI}	-0.0029	-0.36
lnZ_L	δ_{SL}	0.0015	0.95
lnZ_E	δ_{SE}	-0.0069	-1.34
F-statistic		112.01***	
Observations		206	

Note: *** Significant at 1 % level (p<0.01)

** Significant at 5 % level (p<0.05)

* Significant at 10 % level (p<0.10)

Variables P_i' = normalised variable input prices, and Z_k = fixed inputs.

Subscripts F = fertilizer price, W = labour wage, M = mechanical power price, S = seed price, A = land area cultivated, I = experience, L = education, and E = land fragmentation.

Based on the estimation of the restricted translog profit function and four variable input share equations with across-equation restrictions (symmetry) and linear homogeneity imposed.

Table 4. Estimated elasticities of translog profit function

	Mustard price	Fertilizer price	Labour wage	Mechanical power price	Seed price	Land area	Experience	Education	Land fragmentation
Mustard supply	0.6244***	-0.1219***	-0.7195***	-0.1278***	-0.1759***	0.5471	0.0743	0.2603	-0.8524
	(16.24)	(-2.68)	(-7.70)	(-5.36)	(-3.05)	(0.88)	(0.07)	(1.21)	(1.44)
Fertilizer demand	1.0536***	-0.9505***	-0.0801**	-0.0184	-0.0046	0.6054	0.1190	-0.3068	0.4839
	(15.30)	(-48.81)	(-2.09)	(-0.65)	(-0.73)	(0.98)	(0.11)	(-1.44)	(0.83)
Labour demand	1.0087***	0.0027**	-1.1039***	-0.0210	0.0235	0.5449	0.0366	-0.3031	0.7094
	(9.67)	(2.01)	(-10.01)	(-1.57)	(0.57)	(0.88)	(0.04)	(-1.40)	(1.14)
Mechanical power demand	1.0583***	-0.0646*	-0.2432*	-0.7245***	-0.0259	1.0096	0.0843	-0.3644	0.1207
	(6.35)	(-1.73)	(-1.70)	(-13.39)	(-0.92)	(1.48)	(0.08)	(-1.60)	(0.22)
Seed demand	-3.9683***	-0.0248	0.5140	-0.0624	-1.4314**	0.7152	0.2168	-0.3395	-36.2729***
	(-2.92)	(-0.73)	(0.55)	(-0.90)	(-2.04)	(1.06)	(0.19)	(-1.40)	(-10.55)

Note: Elasticity estimates computed at mean values.

Figures in parentheses are t-ratios.

*** Significant at 1 % level (p<0.01)

** Significant at 5 % level (p<0.05)

* Significant at 10 % level (p<0.10)